



**US Army Corps  
of Engineers**

Waterways Experiment  
Station

---

**Preliminary Data Summary  
August 1999  
Field Research Facility**

by Clifford Baron, Michael Leffler, Kent Hathaway,  
Brian Scarborough, Ray Townsend, William Grogg,  
Dan Freer

Coastal and Hydraulics Laboratory



Approved for Public Release; Distribution is Unlimited

Prepared for Headquarters, U.S. Army Corps of Engineers

# Contents

---

1 Introduction . . . . .	1
2 Meteorological Data . . . . .	5
3 Wave Data . . . . .	10
4 Current Data . . . . .	15
5 Visual Observations . . . . .	18
6 Water Levels . . . . .	20
7 Bathymetry . . . . .	22
8 Special Events . . . . .	25

## List of Figures

---

<u>No.</u>		
1	FRF Location Map . . . . .	1
2	Month at a Glance . . . . .	2
3	Instrument Locations at FRF . . . . .	4
4	Meteorological Monthly Summary . . . . .	6
5	Wave Heights and Periods . . . . .	14
6	Water Levels . . . . .	20
7	CRAB Profiles . . . . .	22
8	CRAB Profile Envelope . . . . .	23
9	FRF Bathymetry (19 July 99) . . . . .	24

## List of Tables

---

<u>No.</u>		
1	Instrument Status/Data Availability . . . . .	3
2	Gauge Locations . . . . .	4
3	Meteorological Data . . . . .	7
4	Wave Data . . . . .	11
5	Current Meter Data . . . . .	16
6	Visually Observed Current Data . . . . .	17
7	Visual Observations . . . . .	19
8	Water Levels . . . . .	21

# 1 Introduction

---

The U.S. Army Corps of Engineers Waterways Experiment Station, Coastal and Hydraulics Laboratory (CHL), Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. Central to the FRF is the research pier, a reinforced concrete structure which extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the NGVD (1929 National Geodetic Vertical Datum).

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This is a preliminary which provides basic data soon after collection. Since they are preliminary further quality control may be applied to the data and made available via the internet at <http://www.frf.usace.army.mil>. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919)261-6840 ext.222 ([baronc@wes.army.mil](mailto:baronc@wes.army.mil)).

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8 documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 2.

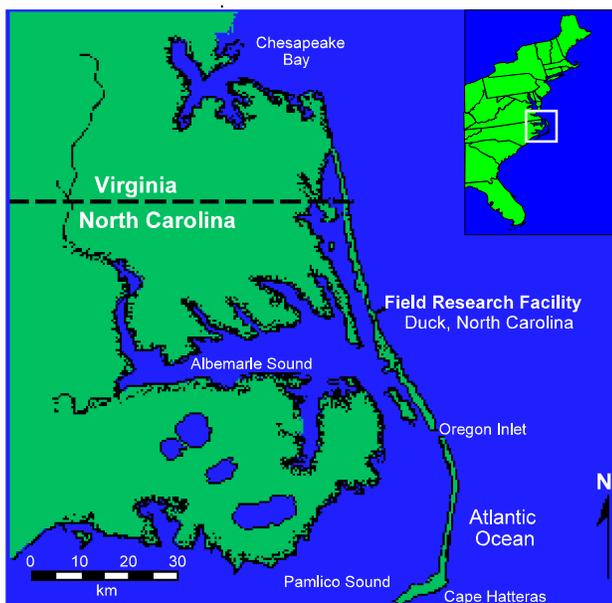


Figure1. FRF Location Map

Times given in the report are referenced to eastern standard time (EST).

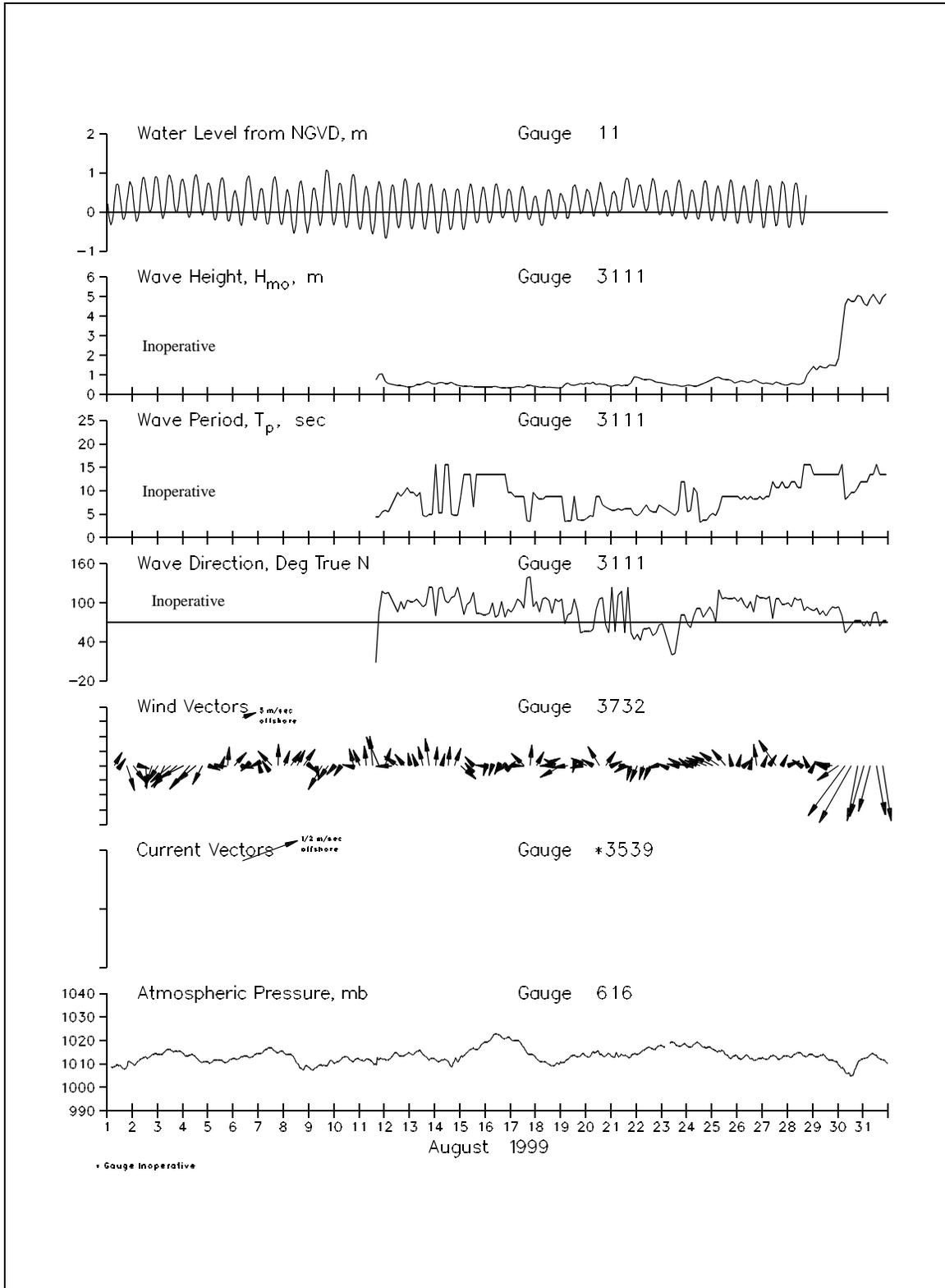


Figure 2. Month at a Glance



**Table 2 Gauge Locations**

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates		Gauge Depth NGVD, m	Water Depth NGVD, m
				Crossshore m	Longshore m		
616	Atmospheric Pressure	36 10' 57.03"	75 45' 5.50"	11.60	569.00	-----	-----
3932	Anemometer	36 11' 1.23"	75 44' 43.07"	585.20	517.30	19.50	-----
641	Pressure Gauge	36 10' 57.71"	75 44' 56.23"	239.11	516.64	-1.64	-1.96
625	Baylor Staff	36 11' 1.04"	75 44' 43.72"	568.00	516.64	Surface	-8.36
3111	8 Meter Array North	36 11' 19.14"	75 44' 36.41"	915.23	990.16	-7.50	-7.90
	8 Meter Array South	36 11' 11.28"	75 44' 33.28"	914.20	735.37	-7.42	-7.90
	8 Meter Array East	36 11' 13.70"	75 44' 32.56"	954.51	800.58	-7.62	-8.13
	8 Meter Array West	36 11' 12.48"	75 44' 37.11"	834.66	800.37	-6.98	-7.44
111	Pressure Gauge in center of 8 M Array	36 11' 14.06"	75 44' 34.39"	914.43	825.52	-7.76	-8.08
630	Waverider Buoy	36 10' 5.10"	75 41' 59.30"	3934.96	-2400.81	Surface	-17.00
3539	Current Meter	36 11' 23.57"	75 44' 9.12"	1605.80	907.60	-11.60	-11.70
11	NOAA Tide Gauge	36 11' 1.25"	75 44' 42.60"	596.49	514.20	Surface	-7.62

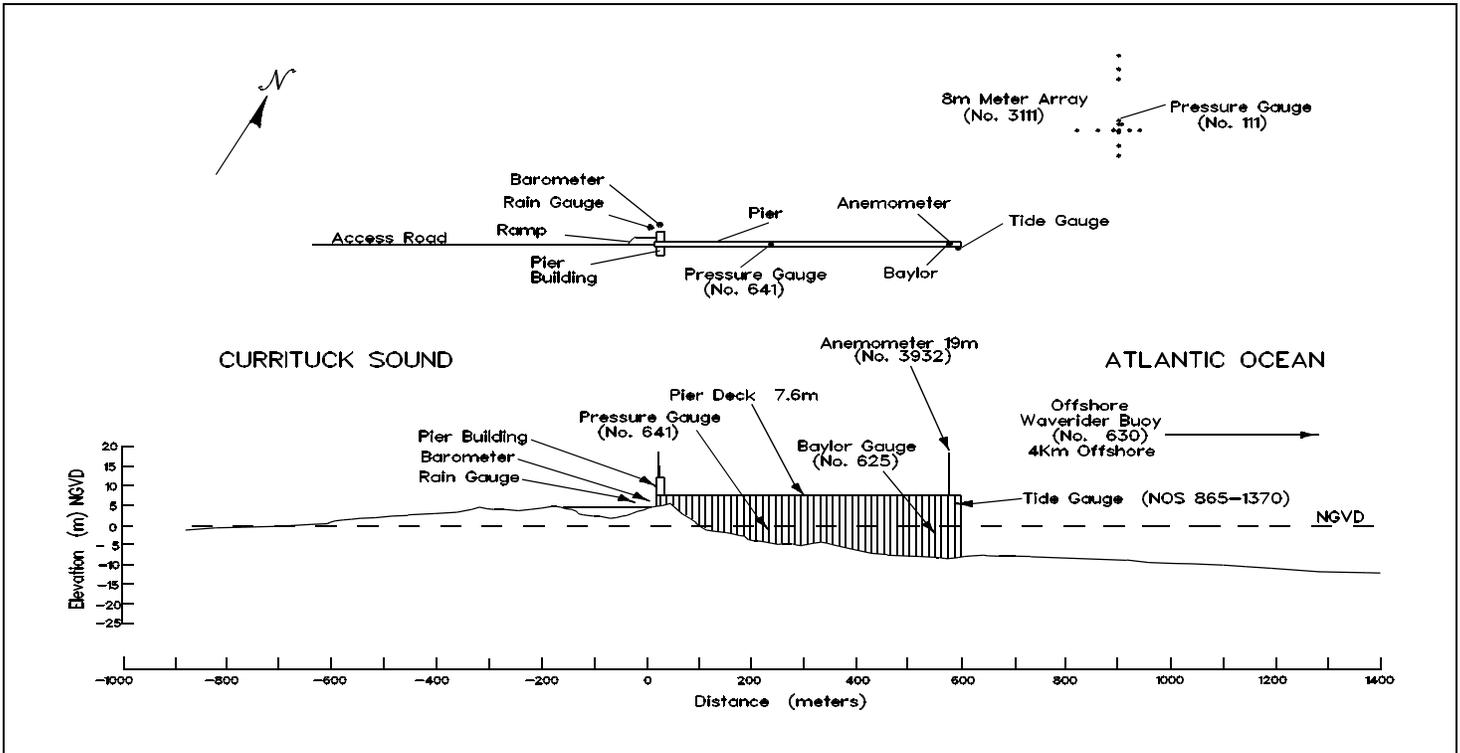


Figure 3. Instrument Locations, Elevations From NGVD

## 2 Meteorological Data

---

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -  
 $\text{mm} \times .03937 = \text{in.}$
2. Millibars (mb) to inches of mercury (in. Hg) -  
 $\text{mb} \times 0.02953 = \text{in. Hg}$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -  
 $(\text{C} \times 9/5) + 32 = \text{F}$
4. Meters per second (m/s) to knots (kn) -  
 $\text{m/s} \times 1.943 = \text{kn}$

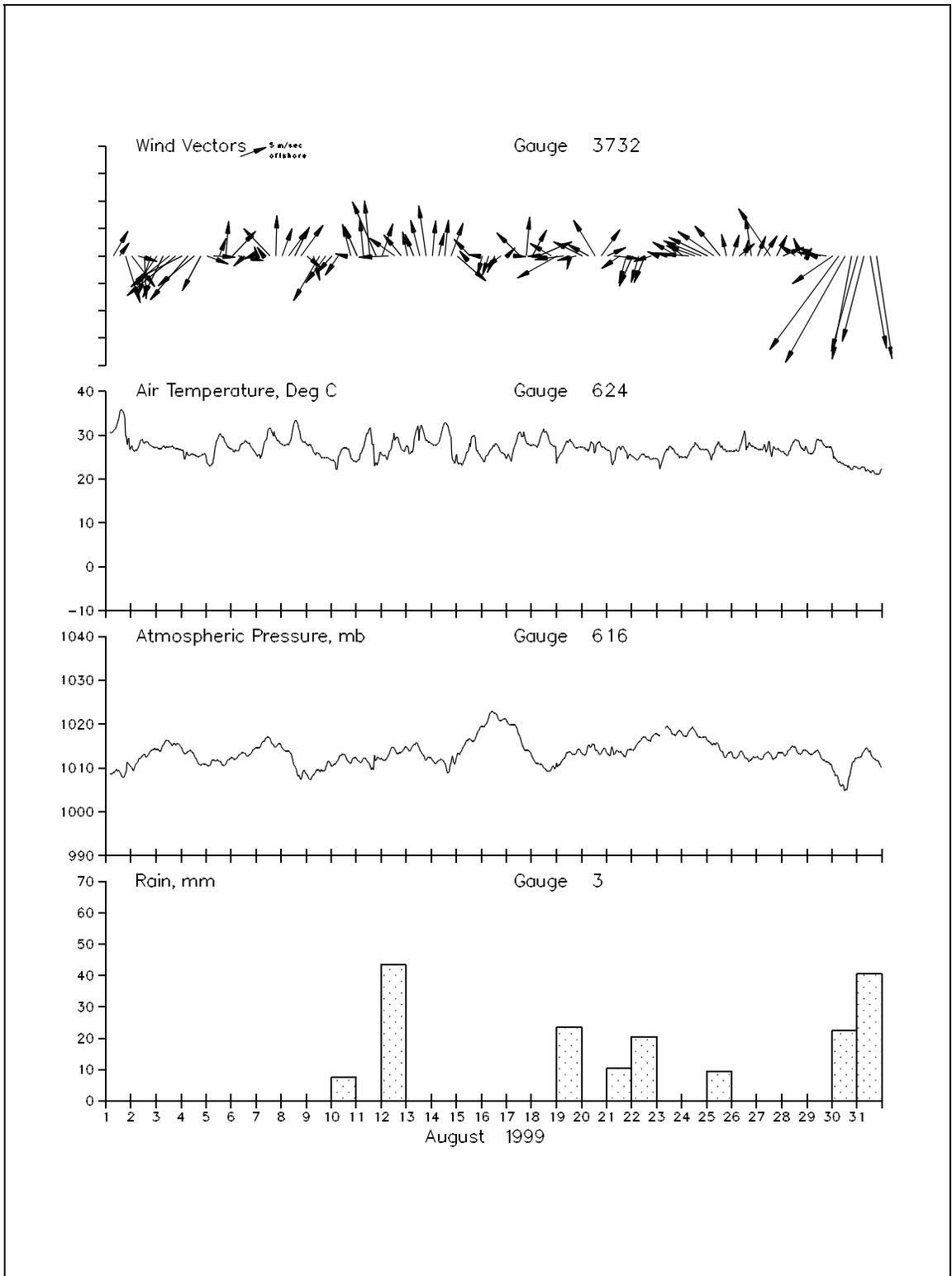


Figure 4. Meteorological Monthly Summary

**Table 3  
Meteorological Data**

Aug 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	16	357	22.6	1009.9	0
	700	5	210	31.0	1009.0	0
	1300	3	216	34.8	1009.3	0
	1900	9	342	29.7	1008.9	0
2	100	7	323	27.7	1010.1	0
	700	4	286	27.1	1011.7	0
	1300	8	357	28.1	1013.3	0
	1900	8	18	27.6	1014.0	0
3	100	6	34	27.2	1014.3	0
	700	8	26	27.5	1015.3	0
	1300	9	51	27.4	1016.0	0
	1900	11	50	26.9	1015.2	0
4	100	9	62	26.6	1014.4	0
	700	11	40	25.6	1013.8	0
	1300	9	50	25.5	1012.8	0
	1900	7	28	25.3	1010.7	0
5	100	4	291	23.8	1010.8	0
	700	4	273	24.3	1011.9	0
	1300	3	200	30.1	1011.5	0
	1900	6	184	28.3	1011.0	0
6	100	6	223	26.8	1012.3	0
	700	5	280	26.5	1012.7	0
	1300	3	45	28.5	1013.4	0
	1900	1	63	27.5	1013.3	0
7	100	2	163	25.3	1014.6	0
	700	2	144	27.4	1016.2	0
	1300	7	136	31.6	1017.0	0
	1900	7	181	29.5	1014.9	0
8	100	5	200	28.0	1014.8	0
	700	6	216	27.7	1014.0	0
	1300	6	207	33.1	1010.5	0
	1900	7	215	29.2	1007.4	0
9	100	3	311	27.8	1008.5	0
	700	5	345	26.2	1008.4	0
	1300	9	30	25.6	1009.2	0
	1900	6	36	24.9	1010.3	0
10	100	4	42	24.2	1010.5	0
	700	4	34	25.1	1012.0	8
	1300	2	102	27.1	1013.1	0
	1900	6	165	24.8	1011.1	0

**Table 3  
Meteorological Data (continued)**

Aug 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	6	156	24.1	1011.9	0
	700	7	174	27.2	1012.3	0
	1300	10	174	31.4	1010.8	0
	1900	11	156	23.8	1012.0	0
12	100	6	198	25.6	1012.1	0
	700	5	87	25.5	1013.1	44
	1300	6	125	28.8	1014.4	0
	1900	5	140	27.0	1013.6	0
13	100	4	169	27.5	1014.6	0
	700	4	158	27.7	1015.4	0
	1300	7	165	31.4	1014.3	0
	1900	9	171	28.7	1011.8	0
14	100	6	185	28.0	1011.8	0
	700	4	193	28.3	1011.8	0
	1300	7	185	32.8	1011.2	0
	1900	6	200	29.6	1011.3	0
15	100	7	311	23.9	1013.4	0
	700	1	139	24.1	1015.0	0
	1300	4	136	28.2	1016.7	0
	1900	1	98	26.9	1017.2	0
16	100	4	14	24.7	1019.5	0
	700	4	17	26.0	1021.7	0
	1300	3	24	27.7	1022.6	0
	1900	4	54	26.1	1020.8	0
17	100	2	223	25.2	1020.5	0
	700	2	273	27.0	1019.9	0
	1300	6	134	30.8	1017.2	0
	1900	7	185	28.4	1014.1	0
18	100	5	208	27.7	1012.5	0
	700	7	246	28.0	1011.1	0
	1300	3	89	30.7	1010.0	0
	1900	4	120	27.9	1009.8	0
19	100	8	60	24.8	1010.3	0
	700	5	82	27.0	1012.2	24
	1300	3	12	29.2	1013.8	0
	1900	4	76	27.0	1013.4	0
20	100	6	116	27.3	1013.3	0
	700	4	118	26.4	1015.3	0
	1300	8	148	26.0	1014.5	0
	1900	6	215	27.5	1013.4	0

**Table 3  
Meteorological Data (concluded)**

Aug 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	4	245	26.6	1013.2	0
	700	5	276	24.1	1013.2	11
	1300	4	55	27.0	1013.6	0
	1900	5	15	26.2	1013.3	0
22	100	6	23	25.2	1014.2	0
	700	5	16	24.8	1016.0	21
	1300	5	22	25.4	1017.1	0
	1900	3	72	24.4	1016.9	0
23	100	2	113	24.6	1017.7	0
	700		inoperative			0
	1300	3	101	27.5	1018.9	0
	1900	5	120	25.8	1017.7	0
24	100	4	130	24.9	1017.7	0
	700	5	94	25.7	1018.3	0
	1300	6	109	28.2	1018.5	0
	1900	7	111	26.7	1017.0	0
25	100	8	115	26.7	1016.2	0
	700	8	124	26.0	1015.7	9
	1300	7	139	27.6	1014.3	0
	1900	4	167	26.1	1012.7	0
26	100	4	197	26.3	1012.8	0
	700	4	231	26.5	1013.0	0
	1300	3	190	30.2	1012.3	0
	1900	7	171	27.5	1011.9	0
27	100	4	201	26.8	1012.6	0
	700	4	213	27.6	1012.9	0
	1300	10	146	26.3	1013.2	0
	1900	4	207	26.7	1012.7	0
28	100	4	247	26.3	1013.5	0
	700	1	329	26.2	1014.2	0
	1300	4	124	29.0	1014.9	0
	1900	4	155	26.9	1013.4	0
29	100	2	206	26.1	1013.7	0
	700	2	110	26.4	1013.6	0
	1300	4	109	28.9	1012.9	0
	1900	5	96	27.4	1011.5	0
30	100	9	55	26.1	1009.6	0
	700	21	36	23.9	1006.8	23
	1300	22	29	23.2	1005.1	0
	1900	19	10	22.1	1010.3	0
31	100	18	15	22.5	1012.5	0
	700	16	14	22.8	1014.0	41
	1300	17	350	21.7	1013.9	0
	1900	19	351	21.2	1011.8	0
		Resultant		Mean	Mean	Total
		1	96	26.8	1013.4	181

### 3 Wave Data

---

Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using an iterative maximum likelihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 Hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height  $H_{mo}$  is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period  $T_p$  is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all  $H_{mo}$  and  $T_p$  values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

**Table 4**  
**Wave Data**

		Aug 1999									
Day	Hour	641		625		3111			630		
		Pressure Gauge Hmo,m	Tp,sec	Baylor Gauge Hmo,m	Tp,sec	8 Meter Array Hmo,m	Tp,sec	Dir,TN	Waverider Hmo,m	Tp,sec	
1	0100	1.87	14.3	3.61	14.3				0.49	10.1	
	0700	0.19	8.9	0.40	8.1	inoperative			0.51	8.4	
	1300	0.19	9.2	0.39	8.9				0.49	8.4	
	1900	0.19	8.9	0.44	9.5				0.48	9.1	
2	0100	0.20	9.5	0.45	8.6				0.55	9.1	
	0700	0.25	3.5	0.51	8.6				0.54	10.1	
	1300	0.87	5.3	1.05	5.4				1.25	5.3	
3	1900	0.89	6.1	1.09	6.5				1.22	6.3	
	0100	0.73	5.6	0.95	6.6				1.10	4.8	
	0700	0.68	6.1	0.93	6.3				1.03	5.1	
	1300	1.03	5.5	1.53	5.4				1.64	5.3	
4	1900	0.98	5.4	1.73	7.0				1.80	5.9	
	0100	1.01	6.5	1.76	7.4				1.82	7.2	
	0700	0.92	4.8	1.59	6.1	inoperative			1.89	6.7	
	1300	0.86	5.6	1.48	6.5				1.66	6.7	
5	1900	0.60	4.9	1.12	6.0				1.33	6.3	
	0100	0.50	7.4	0.92	7.2				0.95	6.7	
	0700	0.26	8.9	0.73	7.0				0.78	7.2	
	1300	0.34	7.4	0.61	7.2				0.69	7.2	
6	1900	0.30	3.9	0.61	7.2				0.85	7.2	
	0100	0.22	7.6	0.44	7.6				0.62	7.2	
	0700	0.14	10.3	0.38	8.3				0.48	10.1	
	1300	0.25	8.6	0.46	8.9				0.57	7.7	
7	1900	0.19	8.3	0.41	8.9				0.52	6.7	
	0100	0.20	8.9	0.41	9.5				0.52	8.4	
	0700	0.17	9.9	0.46	9.5				0.53	9.1	
	1300	0.23	9.5	0.40	8.3				0.55	9.1	
8	1900	0.21	9.2	0.40	9.2	inoperative			0.58	10.1	
	0100	0.18	9.5	0.38	9.5				0.55	10.1	
	0700	0.16	9.5	0.37	9.5				0.50	9.1	
	1300	0.15	9.9	0.31	8.9				0.46	10.1	
9	1900	0.22	3.5	0.38	10.3				0.54	10.1	
	0100	0.13	14.3	0.29	9.5				0.32	10.1	
	0700	0.22	3.1	0.39	3.0				0.43	10.1	
	1300	0.84	5.0	1.07	5.0				1.20	5.1	
10	1900	0.86	6.3	1.05	6.3				1.28	5.9	
	0100	0.57	5.2	0.86	6.3				1.01	6.3	
	0700	0.53	6.1	0.71	4.8				0.76	5.6	
	1300	0.32	6.3	0.56	6.3				0.78	6.3	
	1900	0.32	6.0	0.61	6.3				0.63	5.6	

**Table 4**  
**Wave Data (continued)**

Aug 1999										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
11	0100	0.22	3.3	0.52	6.1	inoperative			0.65	5.9
	0700	0.23	3.4	0.46	8.1				0.58	8.4
	1300	0.27	3.7	0.55	6.8	0.74	4.5	0	0.75	4.1
	1900	0.47	4.4	0.79	4.7	1.01	4.6	86	0.88	4.2
12	0100	0.31	5.7	0.73	6.0	0.68	5.9	114	1.04	5.9
	0700	0.28	4.8	0.51	6.5	0.56	5.5	0	0.57	6.7
	1300	0.18	17.1	0.46	8.9	0.45	9.8	86	0.53	10.6
	1900	0.22	9.9	0.42	8.6	0.42	9.8	90	0.51	9.1
13	0100	0.17	18.3	0.36	9.9	0.39	9.8	102	0.44	10.1
	0700	0.24	9.5	0.45	9.5	0.49	8.9	106	0.52	16.7
	1300	0.25	2.7	0.59	9.5	0.54	4.8	94	0.72	4.8
	1900	0.37	4.5	0.62	4.6	0.64	5.0	124	0.82	5.1
14	0100	0.24	16.0	0.54	5.1	0.53	15.7	80	0.63	5.1
	0700	0.32	5.2	0.60	5.1	0.62	5.3	124	0.76	5.1
	1300	0.27	3.8	0.58	8.9	0.56	15.7	100	0.67	15.4
	1900	0.33	4.9	0.55	5.2	0.54	4.8	110	0.79	4.6
15	0100	0.23	4.7	0.46	15.1	0.44	8.9	104	0.59	14.3
	0700	0.20	14.3	0.37	14.3	0.41	13.6	98	0.48	14.3
	1300	0.20	14.3	0.36	14.3	0.40	6.6	116	0.46	6.7
	1900	0.19	14.3	0.37	7.0	0.40	13.6	84	0.43	6.7
16	0100	0.23	13.5	0.40	13.5	0.40	13.6	82	0.52	4.6
	0700	0.26	5.0	0.47	5.0	0.40	13.6	100	0.62	2.8
	1300	0.22	12.9	0.38	13.5	0.37	13.6	82	0.49	10.1
	1900	0.18	12.2	0.36	12.9	0.32	13.6	78	0.47	12.6
17	0100	0.22	4.6	0.35	9.9	0.34	9.8	86	0.40	9.1
	0700	0.28	4.8	0.43	4.8	0.40	8.9	106	0.44	4.8
	1300	0.23	5.3	0.42	9.2	0.36	8.9	92	0.43	11.8
	1900	0.25	3.5	0.49	3.5	0.48	3.5	140	0.62	3.5
18	0100	0.23	3.5	0.43	9.5	0.42	8.9	102	0.58	9.1
	0700	0.13	9.2	0.35	8.6	0.36	8.2	106	0.46	8.4
	1300	0.16	8.6	0.36	8.3	0.37	8.9	104	0.41	8.4
	1900	0.14	8.9	0.36	7.8	0.35	8.9	106	0.41	8.4
19	0100	0.21	2.6	0.39	8.6	0.34	8.9	106	0.54	8.4
	0700	0.30	3.5	0.68	3.5	0.58	3.6	82	0.70	3.6
	1300	0.27	3.8	0.52	3.6	0.46	8.9	106	0.54	10.1
	1900	0.30	3.5	0.62	3.8	0.56	3.8	54	0.63	3.8
20	0100	0.35	4.2	0.60	4.1	0.58	4.2	56	0.70	4.1
	0700	0.35	4.3	0.68	4.7	0.63	4.6	60	0.70	4.4
	1300	0.39	4.5	0.59	4.7	0.55	8.9	106	0.72	9.1
	1900	0.32	4.8	0.52	6.8	0.50	6.6	66	0.66	5.3

**Table 4**  
**Wave Data (concluded)**

Aug 1999										
Day	Hour	641		625		3111			630	
		Pressure Hmo,m	Gauge Tp,sec	Baylor Hmo,m	Gauge Tp,sec	8 Meter Array			Waverider Hmo,m	Tp,sec
						Hmo,m	Tp,sec	Dir,TN		
21	0100	0.27	5.9	0.42	6.1	0.41	5.9	124	0.54	5.9
	0700	0.30	5.9	0.49	6.3	0.49	6.2	112	0.63	6.3
	1300	0.31	5.5	0.47	6.3	0.48	6.2	54	0.55	5.6
	1900	0.45	6.8	0.57	6.5	0.60	6.2	54	0.59	6.3
22	0100	0.78	5.0	0.93	5.1	0.88	4.8	52	1.08	5.3
	0700	0.64	5.5	0.81	5.7	0.75	6.2	60	0.96	5.6
	1300	0.61	5.9	0.78	6.5	0.77	5.9	62	0.93	6.3
	1900	0.49	5.1	0.67	5.4	0.63	5.6	54	0.79	5.3
23	0100	0.36	4.7	0.58	5.6	0.58	6.6	68	0.63	5.9
	0700	0.33	5.3	0.50	5.1	0.48	5.2	0	0.55	5.6
	1300	0.31	4.9	0.48	4.7	0.49	4.8	22	0.54	5.6
	1900	0.25	4.8	0.45	5.7	0.41	12.0	82	0.53	5.1
24	0100	0.22	4.6	0.47	5.5	0.47	5.6	68	0.55	6.3
	0700	0.25	4.7	0.46	5.7	0.43	10.8	80	0.51	10.6
	1300	0.29	3.1	0.55	3.1	0.49	3.3	92	0.58	3.1
	1900	0.37	4.1	0.65	3.7	0.63	3.8	86	0.72	4.2
25	0100	0.40	4.9	0.79	5.2	0.78	5.3	86	0.90	4.6
	0700	0.51	5.9	0.89	5.6	0.87	6.2	120	1.07	5.9
	1300	0.36	9.2	0.81	9.2	0.75	8.9	108	0.93	8.4
	1900	0.38	9.2	0.72	9.5	0.70	8.9	106	0.90	8.4
26	0100	0.22	9.2	0.60	8.9	0.64	8.9	102	0.76	9.1
	0700	0.35	8.6	0.68	8.1	0.66	8.9	98	0.82	9.1
	1300	0.24	7.0	0.62	8.3	0.64	8.9	102	0.75	6.7
	1900	0.40	8.3	0.67	7.4	0.70	8.2	112	0.86	7.7
27	0100	0.21	10.7	0.54	8.3	0.56	8.2	108	0.72	7.7
	0700	0.29	10.3	0.54	10.3	0.56	8.9	110	0.67	9.1
	1300	0.30	12.2	0.63	11.2	0.63	10.8	106	0.72	11.8
	1900	0.33	11.7	0.55	11.2	0.52	12.0	98	0.62	14.3
28	0100	0.19	11.7	0.46	11.7	0.49	10.8	100	0.56	13.4
	0700	0.32	11.7	0.51	11.7	0.54	12.0	108	0.60	12.6
	1300	0.22	11.2	0.51	11.2	0.53	10.8	106	0.54	11.2
	1900	0.39	16.0	0.77	16.0	1.02	15.7	94	0.81	16.7
29	0100	0.66	15.1	1.16	15.1	1.44	13.6	88	1.16	14.3
	0700	0.75	14.3	1.29	14.3	1.45	13.6	82	1.50	14.3
	1300	0.60	13.5	1.20	13.5	1.35	13.6	80	1.18	13.4
	1900	0.86	13.5	1.66	12.9	1.49	13.6	94	1.38	13.4
30	0100	0.91	15.1	1.74	14.3	1.85	13.6	94	1.91	13.4
	0700	1.71	7.6	3.55	7.6	4.59	8.2	54	4.30	7.2
	1300	1.71	9.5	3.41	9.2	4.77	9.8	66	5.38	9.1
	1900	1.81	11.2	3.63	11.2	5.06	10.8	72	5.80	10.1
31	0100	1.68	11.7	3.27	12.2	4.65	12.0	64	5.10	11.8
	0700	1.74	13.5	3.38	13.5	4.91	13.6	64	5.92	13.4
	1300	1.89	14.3	3.51	15.1	4.86	15.7	86	5.30	15.4
	1900	1.58	14.2	3.22	14.3	4.98	13.6	72	6.11	15.4
Mean		0.45	7.9	0.83	8.1	0.97	8.9	86	1.01	8.2
Std dev		0.40	3.8	0.76	3.1	1.21	3.5	26	1.13	3.2

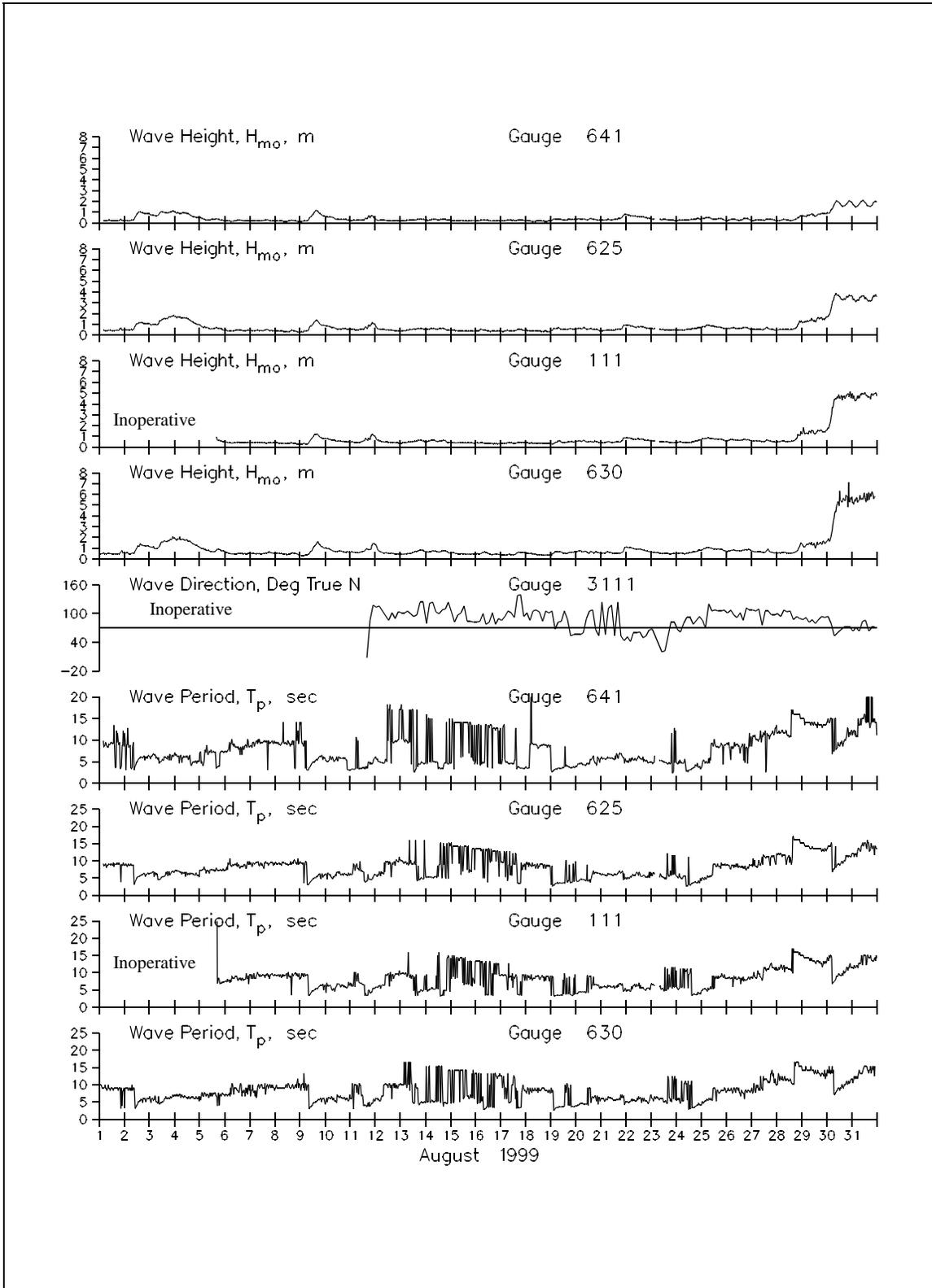


Figure 5. Wave Heights and Periods

## 4 Current Data

---

Current data (Table 5) are collected from a Sontek acoustic current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

**Table 5**  
**Current Meter Data - Gauge 3539**

AUGUST 1999

Cross Long					Cross Long					Cross Long				
Day	Time	Shore	Shore	Speed Dir	Day	Time	Shore	Shore	Speed Dir	Day	Time	Shore	Shore	Speed Dir
1	100					1300				22	100			
	700					1900					700			
	1300				12	100					1300			
	1900					700					1900			
2	100	Data				1300				23	100			
	700					1900					700			
	1300	available			13	100					1300			
	1900					700					1900			
3	100	at a				1300				24	100			
	700					1900					700			
	1300	later			14	100					1300			
	1900					700					1900			
4	100	date				1300				25	100			
	700					1900					700			
	1300				15	100					1300			
	1900					700					1900			
5	100					1300				26	100			
	700					1900					700			
	1300				16	100					1300			
	1900					700					1900			
6	100					1300				27	100			
	700					1900					700			
	1300				17	100					1300			
	1900					700					1900			
7	100					1300				28	100			
	700					1900					700			
	1300				18	100					1300			
	1900					700					1900			
8	100					1300				29	100			
	700					1900					700			
	1300				19	100					1300			
	1900					700					1900			
9	100					1300				30	100			
	700					1900					700			
	1300				20	100					1300			
	1900					700					1900			
10	100					1300				31	100			
	700					1900					700			
	1300				21	100					1300			
	1900					700					1900			
11	100					1300					1900			
	700					1900					1900			

KEY:

+cross-shore = offshore, cm/sec  
 -cross-shore = onshore, cm/sec  
 +longshore = south, cm/sec  
 -longshore = north, cm/sec  
 Speed = Resultant speed, cm/sec  
 Dir = Resultant direction, degrees true north

**Table 6**  
**Visually Observed Current Data**

Aug 1999											
Day	Pier End				Mid-Surf Zone				Beach		
	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir
1	9	29	30	143	6	-10	12	11	South	6	N
2	0	28	28	160	11	17	21	127	North	15	S
3	-15	102	103	169	-6	61	61	166	North	36	S
4	-34	38	51	202	7	23	24	143	North	8	S
5	30	41	51	123	21	61	65	141	South	8	N
6	15	30	34	133	10	34	35	143	North	18	N
7	-3	-68	68	337	-11	-36	37	323	South	38	N
8	18	-61	64	357	0	-23	23	340	South	22	N
9	0	30	30	160	3	29	29	154	North	30	S
10	-5	13	14	182	-6	17	18	179	North	37	S
11	10	-41	42	354	22	-44	49	7	South	61	N
12	-24	41	47	191	-18	30	36	191	South	18	N
13	9	-30	32	357	3	-23	23	349	South	30	N
14	19	-55	59	359	18	-41	45	4	South	41	N
15	2	-10	11	351	4	-12	13	359	South	8	N
16	0	87	87	160	-6	41	41	169	North	26	S
17	12	20	24	129	0	30	30	160	North	10	S
18	15	61	63	146	6	41	41	151	North	10	S
19	-9	30	32	177	-10	38	39	174	South	8	N
20	-9	23	25	182	9	30	32	143	North	6	S
21	29	34	44	120	4	-41	41	346	South	6	N
22	0	51	51	160	0	25	25	160	North	41	S
23	-5	25	26	171	-3	11	11	177	North	10	S
24	-12	-41	42	323	-7	-24	25	323	South	30	N
25	-8	-51	51	331	0	-87	87	340	South	40	N
26	11	-22	24	7	6	-38	39	349	South	46	N
27	13	-22	25	11	0	-30	30	340	South	37	N
28	-6	-21	22	323	-16	-41	44	318	South	11	N
29	-4	15	15	174	-18	-61	64	323	South	13	N
30	no observation				no observation				no observation		
31	no observation				no observation				no observation		

KEY:  
+cross-shore = offshore, cm/sec  
-cross-shore = onshore, cm/sec  
+longshore = south, cm/sec  
-longshore = north, cm/sec  
Speed = Resultant speed, cm/sec  
Dir = Resultant direction, degrees true north

## 5 Visual Observations

---

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

**Table 7**  
**Visual Observations**

Aug 1999								
Day	Time	Wave Approach Angle at Pier End (degrees from True N)		Surf Zone Width, m	Water Characteristics at Pier End			
		Primary	Secondary		Temp., C	Density g/cc	Secchi Vis., m	
1	1201	80	30	13	25.4	1.0200	2.7	
2	0728	60	40	32	28.0	1.0189	6.1	
3	0744	50	355	118	27.0	1.0186	3.0	
4	0710	65	50	225	26.4	1.0172	0.9	
5	0706	70	80	68	26.2	1.0173	0.9	
6	0644	85	115	37	26.7	1.0206	1.5	
7	1205	90	130	12	28.1	1.0198	4.3	
8	1015	95	120	20	24.7	1.0214	1.8	
9	0730	35	140	11	24.7	1.0217	3.7	
10	0649	45	55	23	25.6	1.0205	3.7	
11	0715	130	5	19	25.7	1.0199	2.7	
12	0724	80	50	19	22.7	1.0224	1.2	
13	0720	95	65	14	24.3	1.0217	2.7	
14	1127	110	30	16	22.4	1.0223	1.5	
15	1050	95	55	10	22.2	1.0230	1.8	
16	0654	100	150	15	25.1	1.0188	1.8	
17	0724	45	95	14	26.0	1.0178	3.4	
18	0711	80	90	40	23.2	1.0224	1.5	
19	0714	70	80	50	25.0	1.0215	2.7	
20	0720	60	110	59	26.3	1.0194	2.1	
21	1046	100	30	14	25.7	1.0206	3.7	
22	0920	30	350	51	26.4	1.0197	1.8	
23	0650	50	80	19	25.9	1.0191	5.5	
24	0704	80	110	18	25.8	1.0196	3.7	
25	0655	95		30	26.1	1.0230	2.4	
26	0715	80	65	19	25.1	1.0214	1.8	
27	0650	80	110	14	23.6	1.0219	0.6	
28	0739	125	90	24	23.5	1.0221	4.0	
29	0740	95		108	23.2	1.0224	0.6	
30	0732	no observation						
31	0830	no observation						

## 6 Water Levels

---

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

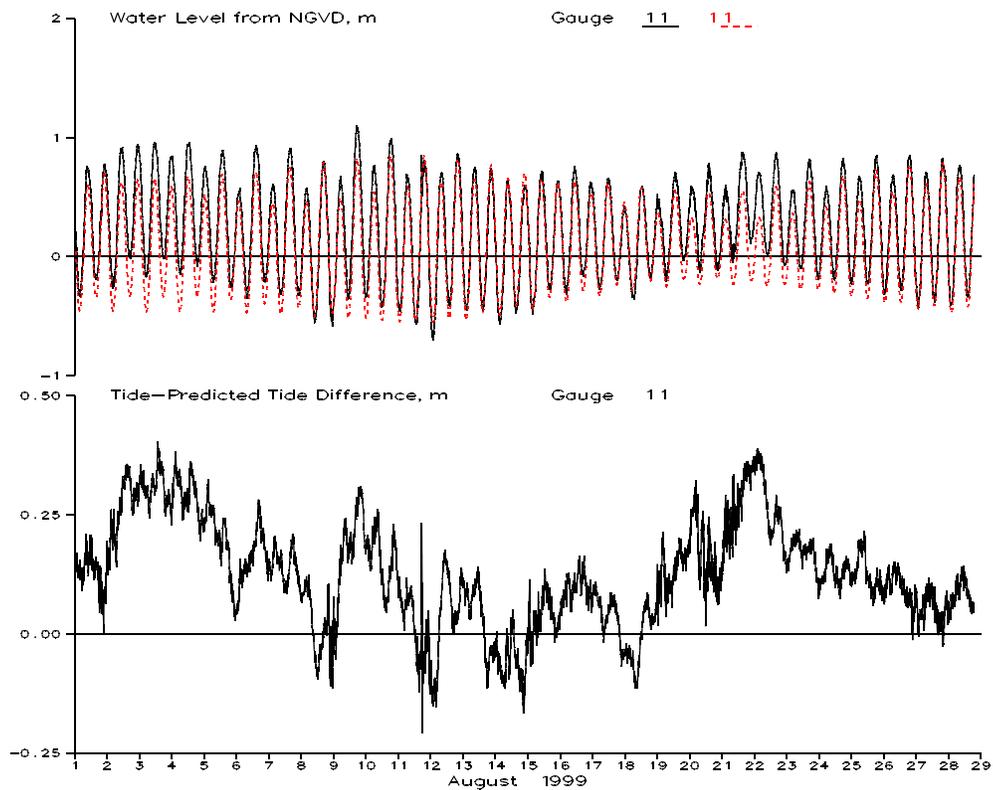


Figure 6. Water Level Variation

**Table 8**  
**Water Levels, m NGVD**

AUG 1999 Tide Levels															
Day	High		Day	Low		Mean m	Range m	Day	High		Day	Low		Mean m	Range m
	Time	m		Time	m				Time	m		Time	m		
1	0912	0.76	1	0400	-0.34	0.22	1.10	15	1024	0.72	15	0324	-0.49	0.14	1.21
1	2224	0.78	1	1618	-0.19	0.28	0.98	15	2200	0.64	15	1648	-0.29	0.18	0.94
2	1124	0.92	2	0406	-0.27	0.34	1.19	16	1048	0.76	16	0442	-0.32	0.22	1.09
2	2242	0.94	2	1718	-0.02	0.45	0.97	16	2230	0.63	16	1712	-0.17	0.22	0.80
3	1106	0.96	3	0512	-0.17	0.41	1.13	17	1154	0.66	17	0512	-0.28	0.19	0.94
4	0030	0.85	3	1848	-0.02	0.42	0.87	17	2342	0.42	17	1818	-0.20	0.09	0.62
4	1300	0.96	4	0612	-0.15	0.42	1.11	18	1248	0.59	18	0636	-0.36	0.12	0.95
5	0042	0.76	4	1854	-0.09	0.34	0.85	19	0006	0.53	18	1906	-0.19	0.16	0.72
5	1348	0.90	5	0654	-0.22	0.34	1.11	19	1306	0.71	19	0624	-0.21	0.28	0.93
6	0236	0.58	5	2036	-0.26	0.15	0.84	20	0124	0.59	19	1906	-0.04	0.28	0.63
6	1454	0.93	6	0800	-0.35	0.31	1.28	20	1418	0.79	20	0736	-0.14	0.32	0.93
7	0300	0.61	6	2136	-0.22	0.20	0.83	21	0230	0.60	20	2054	-0.12	0.23	0.72
7	1554	0.91	7	0836	-0.32	0.28	1.23	21	1506	0.88	21	0742	-0.05	0.44	0.93
8	0400	0.58	7	2224	-0.33	0.12	0.91	22	0324	0.71	21	2106	0.10	0.42	0.60
8	1636	0.80	8	0948	-0.56	0.13	1.36	22	1606	0.88	22	0942	0.00	0.41	0.88
9	0512	0.68	8	2254	-0.59	0.07	1.27	23	0412	0.56	22	2230	-0.08	0.24	0.64
9	1706	1.10	9	1036	-0.36	0.37	1.46	23	1654	0.82	23	1024	-0.10	0.35	0.92
10	0630	0.77	9	2354	-0.35	0.22	1.12	24	0512	0.60	23	2318	-0.20	0.20	0.80
10	1848	0.99	10	1142	-0.43	0.28	1.42	24	1730	0.83	24	1106	-0.20	0.31	1.02
11	0624	0.69	11	0106	-0.47	0.11	1.16	25	0536	0.68	24	2354	-0.23	0.22	0.91
11	1730	0.85	11	1330	-0.57	0.13	1.42	25	1842	0.85	25	1154	-0.23	0.29	1.09
12	0812	0.70	12	0142	-0.71	0.03	1.41	26	0648	0.69	26	0024	-0.32	0.20	1.01
12	1948	0.86	12	1412	-0.42	0.23	1.28	26	1854	0.85	26	1242	-0.29	0.27	1.14
13	0854	0.75	13	0236	-0.45	0.15	1.21	27	0718	0.71	27	0130	-0.43	0.16	1.15
13	2030	0.74	13	1442	-0.45	0.13	1.19	27	1924	0.82	27	1330	-0.39	0.23	1.21
14	0912	0.65	14	0324	-0.57	0.04	1.22	28	0806	0.77	28	0136	-0.41	0.19	1.18
14	2142	0.60	14	1530	-0.48	0.09	1.08	28	1854	0.69	28	1418	-0.34	-0.01	1.03
											29	inoperative			
											30	inoperative			
											31	inoperative			

# 7 Bathymetry

---

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using a Trimble 4000 SSE GPS for positioning, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in November and the survey(s) in August on profile line 188, located 517 m south of the pier.

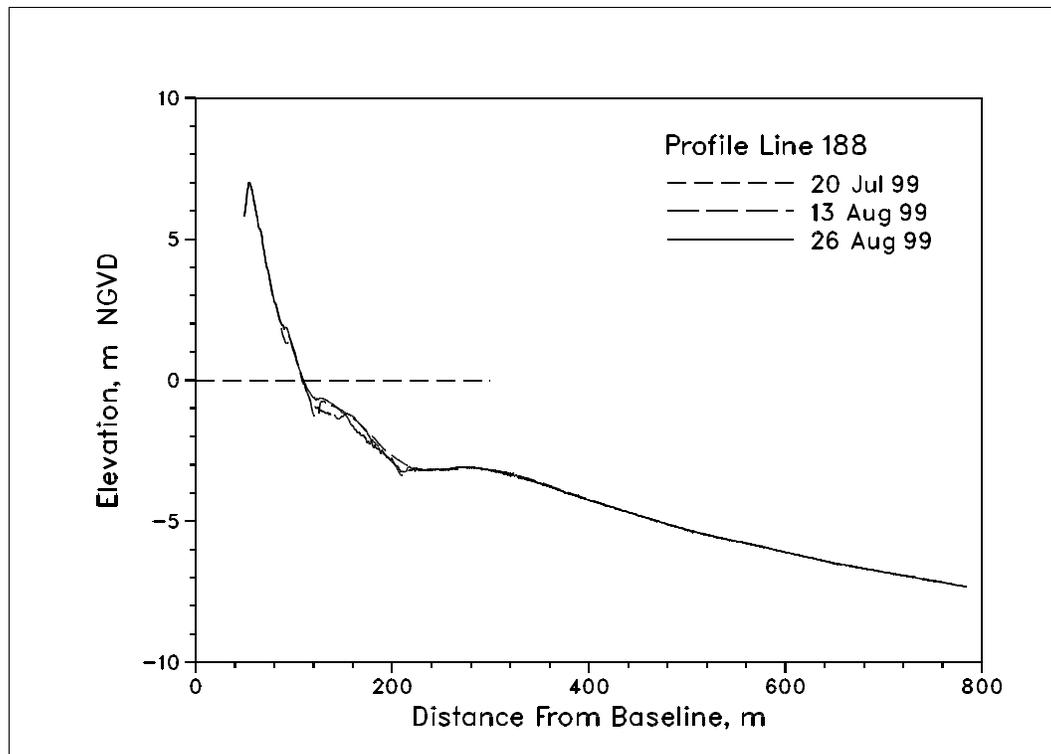


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1999. Cross-hatched areas indicate changes to the annual envelope which occurred in August.

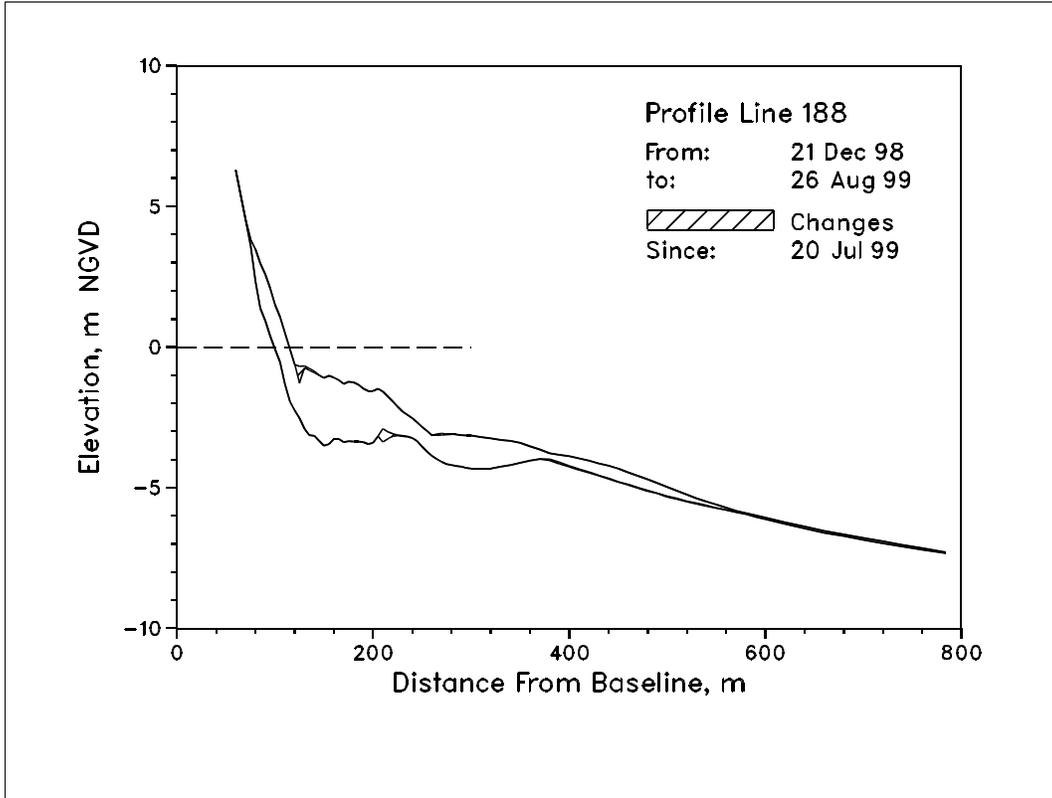


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 19 July. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

There was no bathymetric survey done in August. Figure 9 is included for reference only.

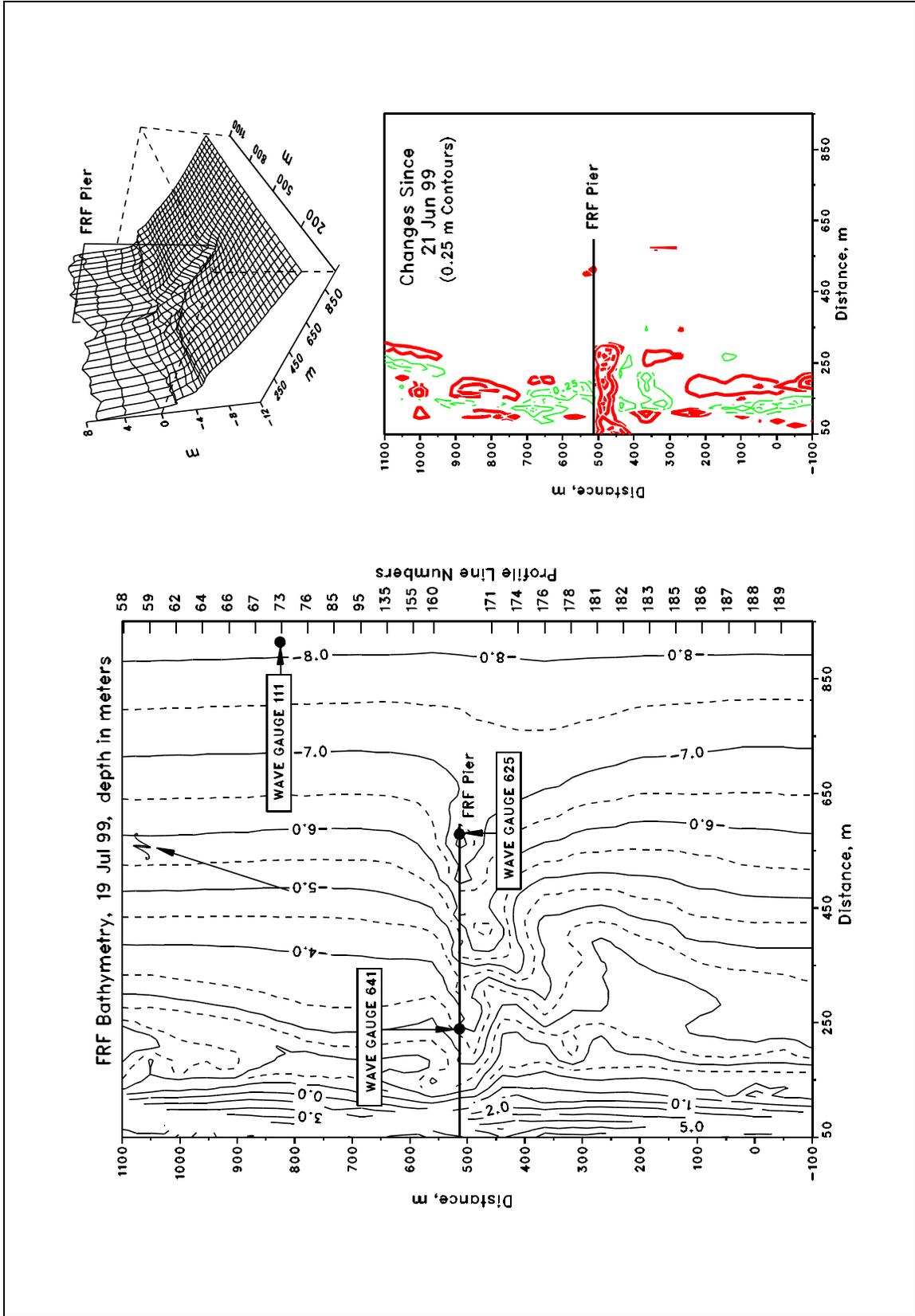


Figure 9. FRF Bathymetry, Depths Relative to NGVD

## 8 Special Events

---

A. Storm Data Collection. The following list identifies times when the wave height  $H_{mo}$  at the seaward end of the pier exceeded 2 m.

<u>Start</u>	<u>End</u>
30 Aug (0242)	05 Sep (0508)

B. Storm Synopsis.

Hurricane Dennis approached from the south, moving north along the Atlantic coast. By the morning of 31 August the storm was situated approximately 200km due east of Cape Hatteras where it remained until 02 September when it had weakened to a tropical storm and began to drift to the south, then west, and finally make landfall by 5 September. Because Dennis remained offshore for such a long time there was significant beach erosion. Maximum onshore winds (NE) reached 24 m/s at 1442 EST on 30 August. The minimum atmospheric pressure was 1004 mb. The maximum  $H_{mo}$ , at gauge 630, reached 6.1 m ( $T_p=15.4$  s) at 1142 EST on 31 August. There was 121 mm of precipitation.